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WINDSOR LAUZON TS TO BELLE RIVER JCT
115 kV TOWER LINE
FOUNDATION INVESTIGATION

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In situ pressuremeter tests were performed at eight selected tower sites along the proposed new 115 kV tower line between Windsor Lauzon TS to Belle River Jct. From these tests the deformation modulus of the soil deposits encountered along the line were determined. The values of the pressuremeter modulus are correlated with the standard penetration and undrained shear strength data to aid in the selection of appropriate soil stiffness coefficients for the design of narrow based tower foundations for this line.

INTRODUCTION

A geotechnical investigation was performed for the proposed new 115 kV tower line along the transmission corridor between Windsor Lauzon TS to Belle River Jct. This tower line will have narrow based structures with a single augered footing per structure. An estimate of the deformation modulus, E or subgrade reaction K_s is required for the design of these foundations. The pressuremeter tests were performed at eight tower sites representing the different soil conditions encountered along this route. The results of these pressuremeter tests and their correlation with the standard penetration or undrained strength values are presented.

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TEST PROGRAM

The pressuremeter test consists of inserting an NX-sized probe in a predrilled test hole and stressing the borehole wall by applying a pressure in increments. The radial deformation of the test hole is measured by recording the probe volume change. The test data was corrected to account for (i) the influence of the membrane inertia and (ii) the differential hydrostatic pressures acting on the probe while performing the pressuremeter test.

The following parameters were calculated from the pressuremeter test data and are summarized in Tables I to VIII:

(a) initial loading deformation modulus, E_i (MPa)
(b) reloading deformation modulus, E_r (MPa)

SOIL CONDITIONS

The primary soil deposit encountered along this transmission corridor consisted of a firm to stiff silty clay with a hard layer of clayey silt in the upper 4 to 6 m depth. The soil conditions were generally uniform for the entire length of the tower line. The boreholes stayed open and no caving conditions were evidenced.

TEST RESULTS

The pressuremeter modulus values ranged from 6 to 35 MPa in the upper layer of desiccated crust whereas in the firm to stiff silty clay below, E, values were in the 3 to 14 MPa range. Tables I to VIII contain the laboratory undrained shear strength and SPT data as reported in the geotechnical data sheets.

A correlation between the Standard Penetration value N and the pressuremeter modulus E_i was attempted for the upper hard layer of the clay deposit (Figure 1). The best fit for this data was obtained with a linear regression. The equation for this regression line is

$$E_i = 0.685\ N \qquad (1)$$

where E_i is the deformation modulus (MPa)

N is the standard penetration value (blows/0.3 m)

For the clay deposit beneath the surficial hard layer, a correlation between the deformation modulus E_i and undrained strength C_u was attempted as shown in Figure 2. The undrained shear strength data used for this correlation was obtained from the laboratory tests on Shelby tube samples as reported in the geotechnical data sheets.

A linear relationship between the deformation moduli E_i and undrained shear strength C_u was obtained as:

$$E_i = 84\ C_u \qquad (2)$$

E to C_u ratio of 100 to 150 was obtained from the laboratory test data for the clay deposit at Lambton GS/1/.

Considerable scatter in the data is present in both correlations (Figures 1 and 2). However, the correlation functions 1 and 2 can be used as a guide in extrapolating the deformation modulus values from the standard penetration values in the upper crust and from the undrained shear strength in the lower deposit, for the tower locations where pressuremeter tests were not performed.

CONCLUSIONS

The proposed transmission line traverses through a clay till plain where the clay deposit has a 4 to 6 m thick layer of desiccated crust at the surface. Based on the results of pressuremeter tests at 8 tower locations, correlations between the deformation modulus and standard penetration/laboratory strength value are developed. These correlation functions can be used for estimating the deformation modulus at other tower locations where pressuremeter tests are not performed.

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REFERENCES

1. T.H. Hana and J.I. Adams. "Comparison of Field and Laboratory Measurement of Modulus of Deformation of Clay:. Highway Research Record No 2433, 1968.

TABLE I

Summary of Pressuremeter Test Results
Windsor Lauzon TS to Belle River Jct 115 kV TL

TOWER NO 258

DEPTH (m)	SOIL DESCRIPTION	UNDRAINED SHEAR STRENGTH (kPa)	PRESSUREMETER MODULUS (MPa)	
			E_I	E_R
2.5	hard brown clayey silt fissured with a little sand and trace of gravel	(N = 28) *	21.4	28.7
3.5	very stiff clayey silt	(N = 20)	10.8	16.3
4.5	firm clay	80	4.0	10.8
6.0	firm clay	72	3.2	12.1
7.5	firm clay	70	3.8	11.2
9.0	firm clay	84	4.9	19.0
10.5	firm clay	89	4.5	14.3

*N = Standard Penetration value (Blows/0.3 m)

TABLE II

Summary of Pressuremeter Test Results
Windsor Lauzon TS to Belle River Jct 115 kV TL

TOWER NO 267

DEPTH (m)	SOIL DESCRIPTION	UNDRAINED SHEAR STRENGTH (kPa)	PRESSUREMETER MODULUS E_I (MPa)	PRESSUREMETER MODULUS E_R (MPa)
1.5	stiff to very stiff clayey silt	(N = 15) *	9.5	11.8
2.5	stiff to very stiff clayey silt	(N = 24)	11.5	36.2
3.5	stiff to very stiff clayey silt	(N = 15)	8.0	18.6
4.5	stiff silty clay	58 (N = 9)	6.9	11.0
6.0	stiff silty clay	49	5.6	10.6
7.5	stiff silty clay	45	4.7	9.3
9.0	stiff silty clay	75	5.6	9.0
10.5	stiff silty clay	(N = 17)	5.0	12.6

*N = Standard Penetration value (Blows/0.3 m)

TABLE III

Summary of Pressuremeter Test Results
Windsor Lauzon TS to Belle River Jct 115 kV TL

TOWER NO 277

DEPTH (m)	SOIL DESCRIPTION	UNDRAINED SHEAR STRENGTH (kPa)	PRESSUREMETER MODULUS E_I (MPa)	PRESSUREMETER MODULUS E_R (MPa)
1.5	firm to stiff clayey silt	47 (N = 6) *	6.6	15.0
2.5	hard clayey silt	(N = 28)	30.3	62.6
3.5	stiff clayey silt	(N = 15)	6.0	17.1
4.5	firm to stiff silty clay	45 (N = 10)	5.0	9.4
6.0	firm silty clay	52	4.5	15.2
7.5	firm silty clay	42	4.7	9.6
9.0	firm silty clay	-	5.3	13.6
10.5	stiff silty clay	86	62	14.9

*N = Standard Penetration value (Blows/0.3 m)

TABLE IV

Summary of Pressuremeter Test Results
Windsor Lauzon TS to Belle River Jct 115 kV TL

TOWER NO 287

DEPTH (m)	SOIL DESCRIPTION	UNDRAINED SHEAR STRENGTH (kPa)	PRESSUREMETER MODULUS E_I (MPa)	PRESSUREMETER MODULUS E_R (MPa)
1.5	stiff clayey silt	(N = 5)*	3.1	6.1
2.5	very stiff to hard clayey silt	(N = 16)	14.5	22.4
3.5	very stiff to hard clayey silt	(N = 17)	17.7	42.5
4.5	very stiff clayey silt	(N = 15	9.4	26.0
6.0	stiff silty clay	72	7.5	16.7
7.5	stiff silty clay	54	7.5	16.6
9.0	stiff silty clay	58	7.2	16.5

*N = Standard Penetration value (Blows/0.3 m)

TABLE V

Summary of Pressuremeter Test Results
Windsor Lauzon TS to Belle River Jct 115 kV TL

TOWER NO 293

DEPTH (m)	SOIL DESCRIPTION	UNDRAINED SHEAR STRENGTH (kPa)	PRESSUREMETER MODULUS E_I (MPa)	PRESSUREMETER MODULUS E_R (MPa)
1.5	stiff clayey silt	(N = 13)*	6.1	19.8
2.5	hard clayey silt	(N = 41)	27.8	54.3
3.5	stiff clayey silt	(N = 22)	9.7	33.1
4.5	firm to stiff silty clay	90 (N = 14)	7.5	13.2
6.0	firm to stiff silty clay	52	5.3	11.8
7.5	firm silty clay	52	4.5 4.5	13.4 11.3
9.0	firm silty clay	56	4.6	15.0
10.5	firm silty clay	N = 10	5.5	16.4

*N = Standard Penetration value (Blows/0.3 m)

TABLE VI

Summary of Pressuremeter Test Results
Windsor Lauzon TS to Belle River Jct 115 kV TL

TOWER NO 303

DEPTH (m)	SOIL DESCRIPTION	UNDRAINED SHEAR STRENGTH (kPa)	PRESSUREMETER MODULUS (MPa)	
			E_I	E_R
1.5	very stiff to hard clayey silt	(N = 18)*	10.0	17.4
2.5	very hard sandy silt till	(N = 39)	32.7	116.0
3.5	very hard sandy silt till	(N = 29)	25.0	36.4
4.5	very stiff clayey silt	(N = 22)	14.7	24.1
6.0	stiff silty clay	89	11.5	19.7
7.5	stiff silty clay	72	8.9	28.3
9.0	stiff silty clay	69	8.1	18.7
10.5	stiff silty clay	57	7.7	19.7

* N = Standard Penetration value (Blows/0.3 m)

TABLE VII

Summary of Pressuremeter Test Results
Windsor Lauzon TS to Belle River Jct 115 kV TL

TOWER NO 314

DEPTH (m)	SOIL DESCRIPTION	UNDRAINED SHEAR STRENGTH (kPa)	PRESSUREMETER MODULUS E_I (MPa)	PRESSUREMETER MODULUS E_R (MPa)
1.5	hard clayey silt	(N = 37)*	23.8	36.9
2.5	hard clayey silt	(N = 45)	34.5	40.1
3.5	hard clayey silt	(N = 29)	16.2	40.1
4.5	hard clayey silt	(N = 27)	14.9	38.2
6.0	very stiff silty clay	167	14.2	41.3
7.5	very stiff silty clay	138	14.0	30.1
9.0	very stiff silty clay	98	10.9	18.5
10.5	firm to stiff silty clay	73	6.5	11.8

*N = Standard Penetration value (Blows/0.3 m)

TABLE VIII

Summary of Pressuremeter Test Results
Windsor Lauzon TS to Belle River Jct 115 kV TL

TOWER NO 343

DEPTH (m)	SOIL DESCRIPTION	UNDRAINED SHEAR STRENGTH (kPa)	PRESSUREMETER MODULUS E_I (MPa)	PRESSUREMETER MODULUS E_R (MPa)
1.5	very stiff clayey silt	(N = 15) *	7.8	14.3
2.5	hard clayey silt till	(N = 30)	25	81.0
3.5	hard clayey silt till	(N = 25)	20.1	77.8
4.5	stiff silty clay	(N = 13)	14.4	18.2
6.0	stiff silty clay	73	9.5	18.3
7.5	stiff silty clay	63	6.0	16.5
9.0	stiff silty clay	59	6.2	17.9
10.5	stiff silty clay	37	4.2	11.9

*N = Standard Penetration value (Blows/0.3 m)

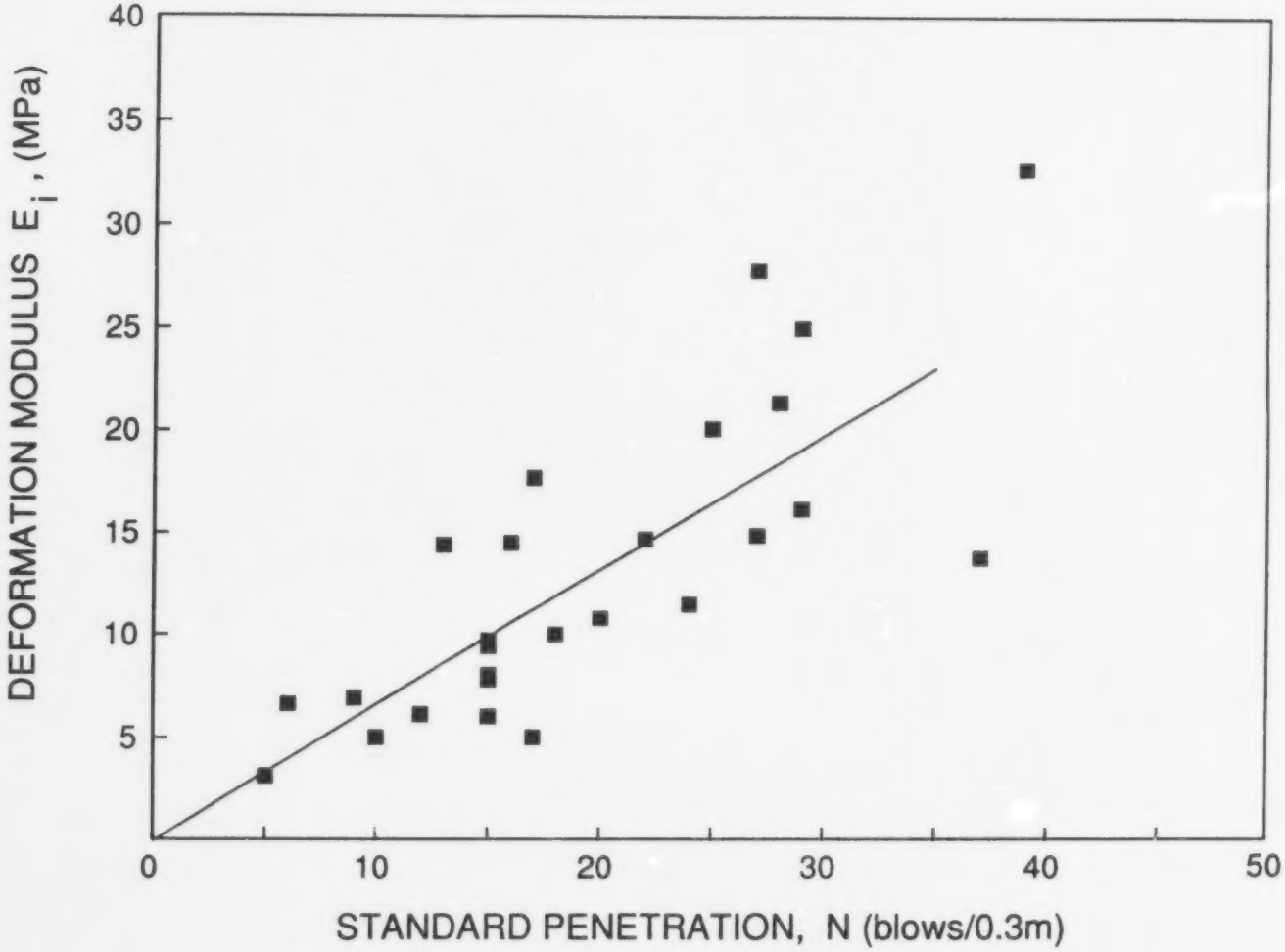

FIGURE 1 CORRELATION BETWEEN E_i AND N.
WINDSOR LAUZON TS - BELLE RIVER JCT.

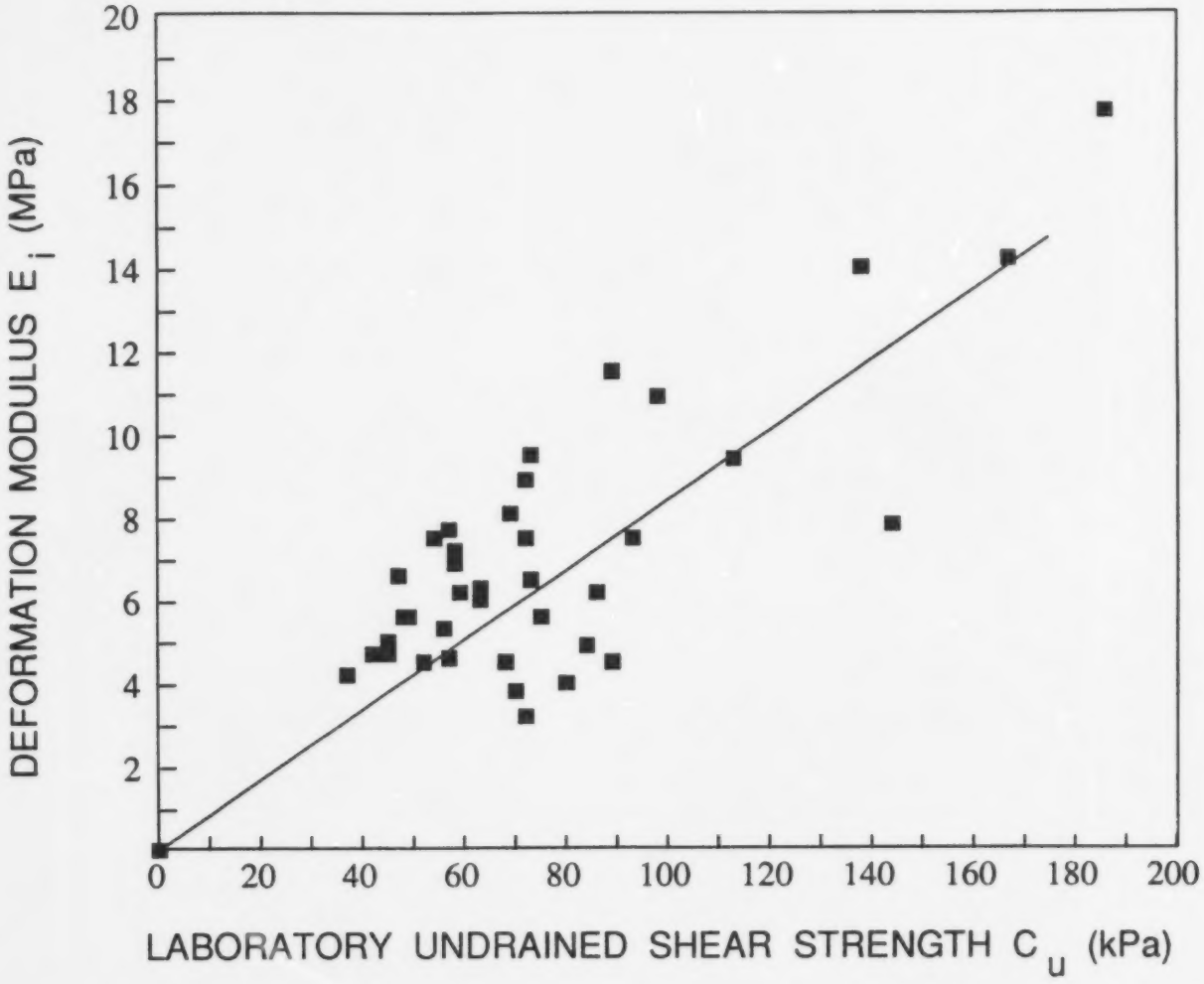

FIGURE 2 CORRELATION BETWEEN E_i AND C_u
WINDSOR LAUZON TS - BELLE RIVER JCT.